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John F. Kennedy Space Center

From Origins to Destiny

U.S. Space Exploration in the Next Century

As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

— 1998 NASA Strategic Plan

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(Photos: Cover photo is Hubble Space Telescope image of the collision between two galaxies known as the Antennae galaxies. Photo above shows the Shuttle Endeavour prior to its maiden launch in May 1992. In the foreground is a full-sized replica of the sailing ship that carried Christopher Columbus and his crew to the New World 500 years before.)

Introduction

The theme for this special issue of *Spaceport News*, *From Origins to Destiny*, comes from the Space Science Strategic Enterprise Plan.

Space Science is one of four strategic enterprises in NASA's Strategic Plan. The other three enterprises are Mission to Planet Earth, Human Exploration and Development of Space, and Aeronautics and Space Transportation Technology.

The complete phrase, taken from the Space Science mission statement, reads: *From origins to destiny, chart the evolution of the universe and understand its galaxies, stars, planets and life*.

All four strategic enterprises encompass this concept in some way. Exploration of the solar system — through both crewed and uncrewed missions — allows us to better understand the evolution of our own planet and life forms as well as of the universe itself. Programs like Mission to Planet Earth also focus on our origins, allowing us to better understand and predict the global changes sweeping over the planet.

The impulse to send humans into space, be it to Earth's orbit, back to the moon, or onward to Mars, perpetuates a quest that has characterized the human race since our beginning.

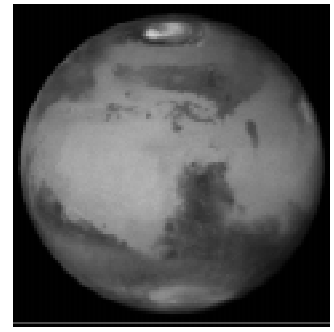
It is humanity's destiny to discover where boundaries lie and then surpass them.

In implementing all these enterprises, we continue to evolve as a nation and culture.

The articles and material presented in this special issue are not intended to be a comprehensive overview of U.S. space exploration in the next century.

Rather they represent a glimpse of some of the most intriguing aspects of what our nation hopes to achieve, as well as a recognition of some of our accomplishments to date.

Space Center sees future in trip to Mars



By Chuck Weirauch

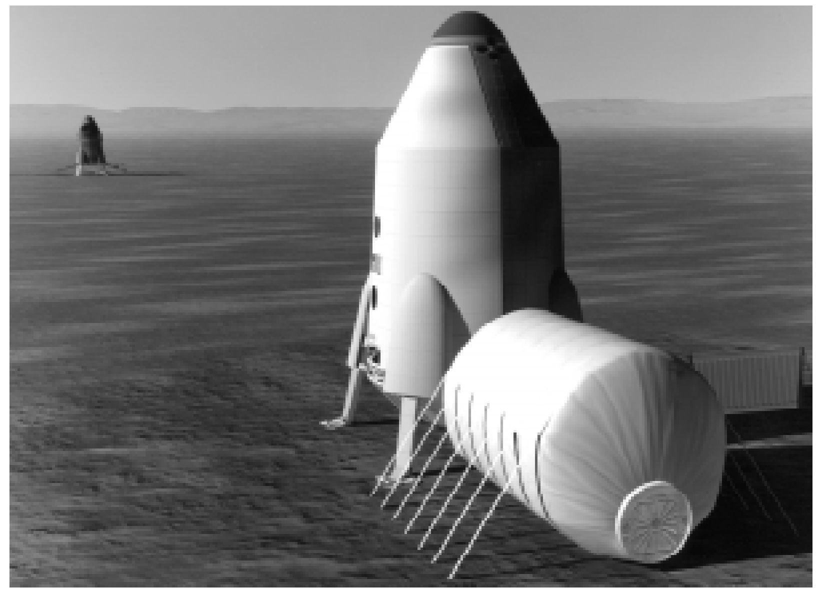
CAPE CANAVERAL — (AP) At 4:25 a.m. Dec. 15, 2013, the first human mission to Mars lifted off from Launch Pad 39B at Kennedy Space Center. The Magnum-1 launch vehicle performed flawlessly as it lofted the six-member international crew into a low-Earth orbit, where their spacecraft docked with the Mars propulsion module launched last month. After docking, the propulsion module engines will be ignited and the crew will begin its 180-day journey to the Red Planet. They will touch down near the Cargo Lander-1, already on the surface, to establish the first human outpost on an extraterrestrial planet. After inflating a habitation module already on Mars, the crew will begin preparations for the 550-day exploration phase of their mission. Orbiting overhead will be the Earth Return Vehicle that will bring them back to Earth when their mission is complete.

Although this quick look at a possible KSC future may seem like science fiction, work is now under way to make the Mars Reference Mission a part of the Space Center's long-range plans.

"We can make a substantial contribution to NASA's newest plan to send a human mission to Mars," said KSC Exploration Think Tank manager Mike O'Neal. "As a member of the agency's Integrated Mars Mission Team, we are now in the process of helping NASA determine what technologies need to be demonstrated for the Mars mission concept."

The Reference Mission, developed by the Mars/Lunar Exploration Office at Johnson Space Center, is not a final plan but a tool to help the agency determine what would be required to accomplish such a feat. Several NASA field centers have been asked to determine just how they could contribute to such a mission. The KSC Exploration Think Tank has the job of determining the areas of applicable KSC expertise and promoting their use by NASA in the development of hardware, new technologies and strategies that will be required for the human exploration of the Red Planet.

"One of KSC's primary areas of expertise that will be of enormous benefit to the Mars mission is more than 30 years of spacecraft ground processing and launch systems experience," O'Neal said. "KSC will be required to put together a plan to support the processing of spacecraft and payloads for the Mars mission, as well as the new heavy launch vehicle that would be required to lift them into space."



ABOVE RIGHT — Hubble Space Telescope image of Mars, March 1997. Above, artist's concept of crewed vehicle on the surface (in foreground) with inflated habitation module in front of it. The living quarters are transported to Mars in the Cargo Lander-1, shown in the distance, then destowed and inflated.

The Reference Mission, an element of NASA's Human Exploration and Development of Space (HEDS) enterprise, calls for a launch vehicle like the Magnum currently under consideration by NASA. This rocket would be designed to place payloads weighing up to 80 metric tons into low Earth orbit. This lift capacity would be sufficient to propel Mars cargo modules, human habitation modules and their respective propulsion modules into low-earth orbit. Once there, the cargo and habitation modules would dock with their propulsion modules and then set off to Mars with the crew on a fast-transit trajectory.

Instead of flying everything that would make up the Mars base along with the crew habitation module, two cargo missions to Mars would be launched well before the first human mission lifted off. The first Mars cargo mission, with an initial launch opportunity in September 2011, would send

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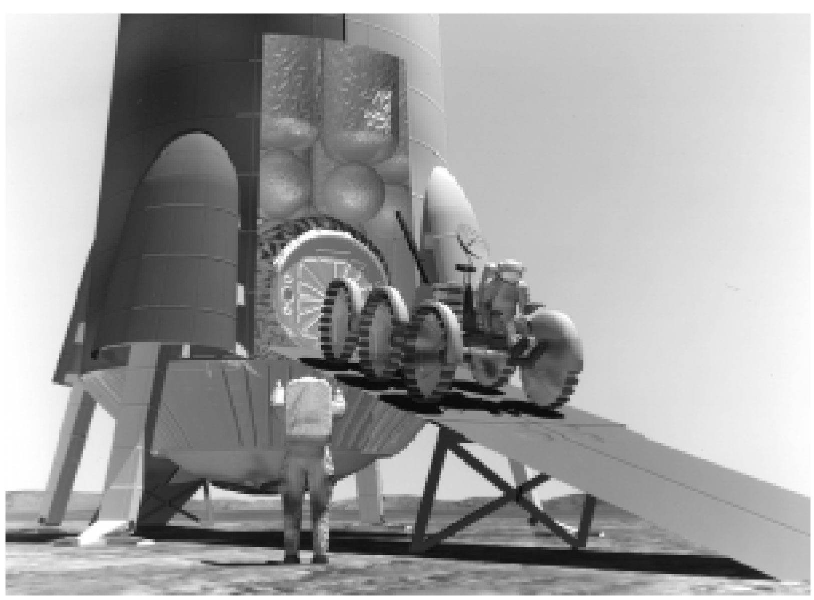

AN unpressurized rover is unloaded from the Cargo Lander-1 by the first humans to land on the Red Planet's surface. The rover would be used to transport an inflatable habitation module from the lander to the transport vehicle that carried the crew to Mars. Visible inside the lander is an automated fuel manufacturing plant.

Mars . . .

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a fully fueled Earth Return Vehicle (ERV) into orbit around Mars. This first cargo mission would take a little more than two years to reach Mars. The second cargo mission, also slated to lift off in late 2011, would land the Cargo Lander-1 on the surface. Inside would be the Mars Ascent Vehicle (MAV). At the conclusion of the exporation phase of their mission, the crew will fly the MAV to the ERV, and return to Earth in the ERV.

Also stowed in the cargo lander: an unpressurized rover for traversing the Martian terrain and an inflatable habitat module. The crew would transfer the inflatable habitat to the spacecraft which brought them to Mars, attach it and then inflate it, establishing their living quarters on the Red Planet.

Also located in the lander would be an automated propellant plant, capable of manufacturing fuel and liquid oxygen (LOX) and storing it in cryogenic tanks prior to the arrival of the first crew. This unit, known as the In-Situ Propellant Production (ISPP) system, would carry liquid hydrogen (LH2) from Earth.

Prior to the crew's arrival, the plant would automatically manufacture methane fuel and LOX oxidizer for the Mars Ascent Vehicle using the on-board LH2 and carbon dioxide found in the Martian atmosphere. (Methane and LOX are leading candidates for propellants, but this is still under review.)

"KSC has the expertise in the cryogenics, autonomous systems and remote monitoring disciplines that would be required for the development of the ISPP," O'Neal said.

To sustain the crew in their habitat for an approximately one-and-a-half-year stay on the surface, an advanced type of life support system will have to be designed and developed. According to the latest version of the Mars Reference Mission, this system and its primary backup would be mostly based on a physical/chemical system such as the one on the Shuttle to scrub impurities from the crew supply of air and water, while the second backup system would rely on stored supplies.

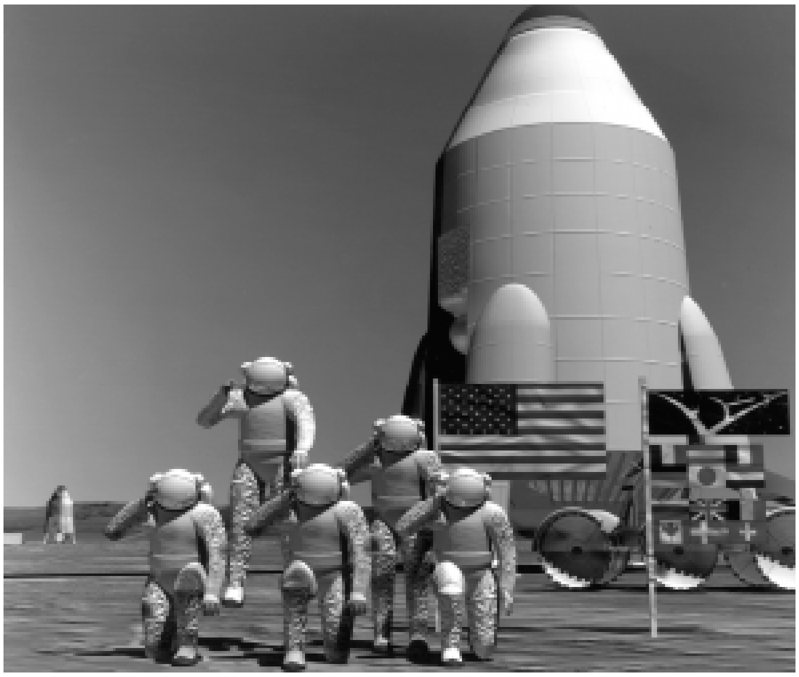
"However, the Reference Mission also states that demonstrating the ability to produce food and revitalize the air in the Mars habitat is a mission-critical objective," O'Neal said. "We feel that KSC can also make a substantial technological impact on the bioregenerative part of the mission because of our considerable experience in this area."

Since 1985, KSC has been developing and conducting research on such a self-contained, plant growth-based life support system formerly known as the Controlled Ecological Life Support System (CELSS) Breadboard Project. This project is now called the Bioregenerative Research Lead of NASA's Advanced Life Support Systems.

"There are many other areas of expertise at KSC where we can have a major impact on NASA's Mars and other long-duration missions in the future," O'Neal said. "Our goal is to apply KSC operations know-how, resources and technical expertise to help enable the human exploration of the solar system while delivering world-class products."

NOT THAT FAR AWAY — This artist's concept shows five of the six crew members from the first human mission to Mars. The Mars Reference Mission timeline would be:

• 2011 – Fully fueled Earth Return Vehicle lifts off, arrives at Mars about six months later and begins orbiting planet;
• 2011 – Second mission, called Cargo Lander-1, lifts off, carrying Mars Ascent Vehicle that will land on surface. Also stowed inside are rover, propellant plant, and inflatable habitat module;
• 2013 — First human crew lifts off, lands on Mars 180 days later to begin 550-day exploration of Martian surface.



On matters of food ...

KSC scientists favor plant-based life support

If KSC Life Sciences researchers have their way, the science-fiction vision of greenhouse-grown plants sustaining a colony of Mars explorers just may become reality.

"We believe that on a Mars mission where the crew would be on the surface of the planet for more than 500 days, the life support system for the crew should be mostly bioregenerative," said Life Sciences agricultural engineer Dr. John Sager. "The most current version of the

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... and fuel.

Fuel supply will borrow from Earth and Mars

Just as early explorers of the North American continent learned to bring along only what was essential for survival and to live off the land for the rest, so too will the first Mars mission crews and future residents of a Mars colony.

"This philosophy of living off the land is the basis for NASA's new Mars Reference Mission and will provide the necessary resources required for the possible colonization of the planet," said KSC Exploration Think Tank member Robert Johnson. He is also the KSC lead for NASA's In-Situ Propellant Production (ISPP) Team at Johnson Space Center and chief of the Process Engineering Directorate's Main Propulsion/ Space Shuttle Main Engine (SSME) Branch. "The ISPP is a perfect example of how KSC's expertise can be used to support future NASA missions."

The ISPP is a critical element of the

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